" Hannah Calline's Jim," and an essay on " Simplicity," by Charles Dudley Warner, close the prose articles; and the poetry includes Mr. Whittier's " The Christmas of 1888," and verses by E. Wilson.

LETTERS TO THE EDITOR.

***Correspondents are requested to be as brief as possible. The writer's name is in all cases required as proof of good faith.*

Twenty copies of the number containing his communication will be furnished free to any correspondent on request.

The editor will be glad to publish any queries consonant with the character of the journal.

The Soaring of Birds.

SINCE my paper was reported in *Science* (xii. p. 267), Messrs. Oliver, Pickering, and MacGregor have favored the journal with letters on the subject.

Professor Oliver (xiii. p. 15), while admitting that the action I suggest is to some extent efficient in sustaining the bird, questions its sufficiency. I had asked the same question myself, and found no answer; but I am glad to know, through private correspondence, that Professor Oliver and at least one other physicist are disposed to put the question to nature through experimentation.

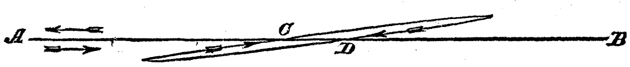
Professor Oliver also suggests minute vibratory motions of the wings, or perhaps of the individual wing-feathers, and cites an observation by another. The same hypothesis was advanced in explanation of the allied phenomenon of hovering, but was rejected on the strength of what seemed sufficient observation (*Nature*, viii. p. 324; ix. p. 5). The hovering bird remains in one place for so long a period that he can be deliberately and carefully watched.

Mr. Pickering and Professor MacGregor each proposes an explanation different from mine, and not involving differential air movements, but appealing instead to a homogeneous and uniform wind. Their conception of relative velocities is so different from mine, and I am so confident in the correctness of my own, that I am led to suspect I have not made my meaning clear, and I therefore ask the privilege of restatement.

As I conceive the matter, the horizontal velocity of the bird with reference to the earth has no importance, and should be ignored. The earth enters the problem only by means of its attraction. Except for the gravitational pull, we need not consider the bird in relation to any thing except the air. If a cloud intervened between the bird and the earth, so that he could not see the ground, he would not know in which direction the air surrounding him was passing over the earth; but the possibility of his soaring would not be affected by that ignorance. Provided the air in which the bird floats is not disturbed thereby, his motions would not be affected by the sudden reversal of the direction of rotation of the earth, although such a reversal would enormously change the relative velocity of bird and earth.

In my analysis of the subject I spoke of winds, that is, currents of air moving horizontally with reference to the earth, because such language afforded me a simple means of expression, and for that reason only. In so doing I took a special case as illustrative of the general case. As this seems to have been misunderstood by some of your correspondents, I will repeat the analysis in more general language.

Let the line AB represent in section a horizontal plane within the atmosphere. Conceive the body of air above this plane and the body of air below it to have different motions, such that their differential motion has the direction indicated by the arrows; that is



to say, the upper body referred to the lower moves from B to A, or the lower body referred to the upper moves from A to B. The movement of the two bodies collectively may be in any horizontal direction. They may both move toward A, the upper moving the swifter. They may both move toward B, the upper moving the slower. Either may be still and the other move past it, or they may move in directions approximately normal to the paper. My only postulates are, that their motions have no vertical component, and that their differential motion, i, has the direction expressed by the arrows.

The oval curve represents the assumed orbit of the bird as presented to an eye nearly in its plane. The bird ascending on one side of this orbit through the point C has, just before reaching that point, a velocity V as referred to the lower body of air, in which it is then moving. Immediately after passing C, his velocity referred to the upper body of air, in which he is then immersed, is $V + i$. He moves faster in the upper air, because when he enters it his direction is opposed to the direction of the differential motion of the upper air referred to the lower. His absolute motion both before and after passing the plane of separation is the same; but his relative velocity, that is, his velocity referred to the air through which he is passing, has been increased by the quantity i. Continuing on his circling orbit, he first ascends and then descends, reaching the plane of separation at the point D. While he ascends, gravity retards his motion; while he descends, his motion is accelerated by gravity to the same extent; so that he returns to the plane at D with the same velocity ($V + i$) with which he left it at C. He now passes from the upper body of air to the lower body in such direction that he again increases his relative velocity. As soon as he has passed D, his velocity referred to the lower air is $V + 2i$. Continuing to C, he first descends and then ascends, his velocity being first accelerated by gravitation, and then retarded by the same amount; so that he reaches C with the velocity $V + 2i$, in place of the previous velocity V, having gained the velocity $2i$ by passing in suitable directions to and fro between the differentially moving bodies of air.

The various qualifications of this theorem, and its relation to the problem of soaring, need not be repeated here. All that is now attempted is to show that the essential parts of the analysis are absolutely independent of the direction and velocity of air movement as referred to the ground.

It appears to me that Mr. Pickering and Professor MacGregor, by referring the motions of the bird partly to the ground and partly to the air, engender confusion, and are led to assume untenable positions. Mr. Pickering (xiii. p. 31) says that a piece of paper floating on the air is carried along horizontally with the velocity of the wind, but that a soaring bird does not drift so fast. Then, to account for the floatation of the bird, he appeals to the "force exerted on him by the wind, owing to the fact that he does not move along as fast as the surrounding air." Thus he assumes a force tending to prevent the bird from drifting horizontally with reference to the earth; and this assumption reduces the problem to practical identity with the problem of the ascent of a boy's kite. In point of fact, the assumed force does not exist: the only re-action between the bird and the earth is through gravity, and the direction of gravitation is vertical. If it be true that the soaring bird drifts less rapidly than the piece of paper, the explanation lies in something that the bird does; and that thing, whatever it is, costs energy. Appealing to the bird's net movement against the wind as a source of energy merely shifts the point of difficulty, for his net movement against the wind must then be explained.

Professor MacGregor says, " Let us suppose, now, that a bird is at any instant moving horizontally, in the same direction as the wind, and with a small velocity relative to the earth. . . . As his speed increases, the velocity of the wind relative to him diminishes" (xiii. p. 152). Now, if the velocities of bird and wind relative to the earth are so related that increase of the bird's speed diminishes the velocity of the wind relative to him, then it must be that the wind is moving faster than the bird, or is overtaking him. The context shows that Professor MacGregor conceives the bird to face in the direction toward which the wind blows, and it follows that with reference to the air the bird is moving tail first. I am confident that no ornithologist will admit the possibility of such flight; and its implicit postulation could hardly have occurred had the problem been stated wholly in terms of bird and air instead of being stated partly in terms of bird and ground. A little further on he says, " Let us suppose that in wheeling he maintains his velocity relative to the earth as well as his elevation. Then [after wheeling], starting upwards with a considerable velocity, he will clearly be able to rise through a certain height before his velocity has been reduced to its initial value." The assumption that the bird in wheeling maintains his velocity relative to the earth

appears to me absolutely groundless. The only velocity that can possibly remain constant, or approximately constant, during wheeling, is the velocity with reference to the supporting medium; and as that velocity is, according to his previous assumption, not only small, but negative, there is no energy available to enable the bird to rise. Indeed, the bird, in passing from a negative velocity relative to the air, to a positive velocity relative to the air, must pass through the phase of no velocity relative to the air, in which he is practically helpless, being compelled to fall vertically in order to acquire sufficient speed to steer. Like Mr. Pickering, Professor MacGregor treats the subject as though the earth influenced the motions of a bird on the wing by some other means than gravitational attraction. He apparently fails to perceive, that, if the body of air in which the bird moves has no internal motion, its relation to his flight is precisely that of a calm.

Let me illustrate. A steamer propelled with uniform force on a calm ocean has its rudder turned constantly, and by the same amount, to the right, and consequently describes a circle. This circle is described *on the ocean:* it expresses a relation between the moving body and that by which it is supported. It has no reference to the bottom of the ocean. It makes no difference whether that part of the ocean is at rest or is part of a swift current. The relation of the boat to the water is not affected by the relative motion of water and bottom. Or consider a skater. Having acquired momentum, he is able to describe circles without propulsive effort until the stored-up energy is consumed by friction and by the resistance of the air. The ice on which he circles may be frozen to the shores of a pond, or it may float with uniform speed on a rapid river; but his relation to the ice is the same in either case, and his circles have the same pattern *as engraved on the ice.* The case of the soaring bird is closely analogous. His horizontal motions are related only to the air in which he moves, and by which he is supported, and they are not affected by the uniform horizontal motion of that air with reference to the ground.

A slight correction, and I have done. I assume, as Professor MacGregor says, that after wheeling, the bird's velocity relative to the medium in which he turns will be the same as before (discounting friction); but I do not admit the implication "that during the turn his velocity relative to the earth will change by an amount equal to twice the velocity, relative to the earth, of the medium in which the turn is made." His velocity relative to the earth will change by an amount equal to twice his velocity relative to the medium.

G. K. GILBERT.

Washington, D.C., Feb. 25.

IN two communications published in the last number of *Science* (p. 151) under the above title, Professor Pickering and Professor MacGregor have developed with considerable ingenuity a theory of the possibility of a bird soaring in a uniform horizontal wind; but it is certainly true that a bird cannot soar — that is, permanently sustain or elevate itself without expending energy — in such a wind, and it has therefore seemed to me to be important, in the interests of clear thinking, to show on dynamical grounds why soaring is impossible in this case.

Evidently the velocity of the wind relative to the earth has nothing to do with the question, as it is the relative movement of wind and bird that causes the re-actions between them, and therefore can alone come into consideration. Let the air, therefore, be supposed to be at rest relative to the earth, and it becomes at once obvious that the bird cannot soar: for, suppose the bird to have any imaginable initial velocity, and to wheel in the most artful manner, it is still a mass falling under the influence of gravity, and only resisted more or less by the fluid friction of the medium in which it is placed. This fluid friction of the air against its wings can only delay its fall, but can never prevent it, just as it delays the fall of a feather.

A theory of soaring must explain how energy is given to the bird by the wind; but it is clear, that, instead of the bird receiving energy, it is expending either its kinetic energy, as when in one of its whirls it sweeps upwards, or potential energy when it sweeps downwards. But the temporary increase of potential energy in a rise can never equal the corresponding loss of kinetic energy, because energy is being continually expended in frictional heating. There is thus a steady expenditure of energy, and none received from the medium, and the bird is therefore bound to come to the ground. The only effect of the medium is to resist the motion, in whatever direction it may take place, whether up or down.

As soon as it is clearly seen that the only thing we are concerned with is the relative motion of air and bird, and that the air may be at rest relative to the earth without affecting the question in the slightest, the futility of any attempts to explain soaring in a uniform horizontal wind is apparent.

If any one wishes to discover the particular fallacies in the theories above mentioned, let him attempt to follow out the reasoning as given in the communications referred to; assuming, however, that there is no wind, that the air is at rest relative to the earth; remembering that the mere fact of the earth's moving relative to the wind has no connection with the relation between the bird and the air.

The theory that soaring can be kept up by taking advantage of differentially moving layers of air is not open to the above criticism, and may be the true explanation: it is certainly not unreasonable on its face.

ARTHUR L. KIMBALL.

Johns Hopkins University, Baltimore, Feb. 23.

To keep Water-Mounts Moist.

IN biological work with the microscope it is frequently desirable to preserve water-mounts for several days, that growth, development, etc., may be observed from time to time. Water lost by evaporation can be very successfully replaced to the glass slips from a beaker beneath by means of capillary tubes. To make these, hard-glass tubing of about three millimetres bore is softened in a Bunsen flame, and then drawn out to a diameter of from two-tenths to three-tenths of a millimetre. This is then divided up into lengths of five centimetres, and each piece bent at an angle of about 80° one centimetre from an end by holding it over a very small flame for an instant, when, of its own weight, the end falls to the proper angle. One tube is sufficient for a slip, and is applied by first touching the longer limb in water, when instantly the liquid will rise and fill the tube, which may now be suspended by the shorter portion from the glass slip, allowing one end to just touch the edge of the cover-glass, and the other to dip beneath the surface of the water in the beaker. A thin film of water will run along the shorter limb, and hold it securely in place. The whole is then covered with a suitable bell-jar. In this way mountings in water or nourishing solutions may be kept an indefinite time, and are always ready for examination without disturbing them in the least. Should it be desired to supply more fresh water or nourishing solution to the mount than would ordinarily arise, a bit of filter-paper applied to the side of the cover-glass opposite the capillary tube will accomplish this.

E. B. KNERR.

Parsons College, Fairfield, Io., Feb. 18.

Color-Blindness a Product of Civilization.

THE following is a summary of a paper read before the Kansas Academy of Science at Leavenworth, Nov. 1, 1888: —

The fact that blindness to certain colors exists among civilized people is well established; also the percentage of cases to be found among males has been determined with considerable probability for the races of Europe and America. There has been much diversity in methods of testing, and the results of many reported determinations might well be called into question. Still it is probably not far from the truth that about four out of every hundred males are more or less deficient in color-sense. Of females there have been reported (B. J. JEFFRIES, M.D., *Color-Blindness*, p. 74) as examined in Europe and America 39,828; and of these, only 60 were color-blind, or 2 per cent. Of both males and females, 156,732 have been tested; and of these, 6,721, or 4.27 per cent, are color-blind. These statistical facts have naturally excited interest and discussion. If so large a number as four out of every hundred are unable to distinguish colors, there arises, of course, a practical question important to the railroads, marine, etc.

The gravity of this fact is already recognized more or less in all countries by the test examinations for color-blindness among employees. But there is in these statistics also much of interest to scientists.